AD-773 611

AN INVESTIGATION OF AIRBORNE DISPLAYS AND CONTROLS FOR SEARCH AND RESCUE (SAR). VOLUME VIII. ARMY MEDEVAC AVIONICS CAPABILITY STUDY

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Honeywell, Incorporated

Prepared for:

Joint Army-Navy Instrumentation Project

September 1973

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: JANAIR Report No. 731001	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER: AD 773611	
4. TITLE (and Subtitle): AN INVESTIGATION OF AIRBORNE DISPLAYS AND CONTROLS FOR SEARCH AND RESCUE (Vol. VIII, Army MEDEVAC Avionics Capability Study)	5. TYPE OF REPORT & PERIOD COVERED: Final Report Nov 1972 through Aug 1973
	6. PERFORMING ORG. REPORT NUMBER: 12609-FR1 (Vol. VIII)
7. AUTHOR(s): A.L. Jones, W.A. Dalhamer, R.J. Kirk	8. CONTRACT OR GRANT NUMBER(s): N00014-69-C-0460
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Honeywell Inc. 2600 Ridgway Parkway Minneapolis, Minnesota 55413	10. PROGRAM ELEMENT PROJECT, TASK AREA & WORK UNIT NUMBERS: NR213-072
11. CONTROLLING OFFICE NAME AND ADDRESS: Office of Naval Research, Code 461, Department of Navy	12. REPORT DATE: September 1973
	13. NUMBER OF PAGES: 42
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS (of this report): Unclassified
	15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Joint Services SAR Working Group Program

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

MEDEVAC, MAST, Night-Vision Goggles, UH-1H

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents results of a study to assess the avionics capability of the present generation ARMY MEDEVAC helicopters (UH-1H). The study was based on interviews with experienced MEDEVAC pilots. Analyses were performed to evaluate the baseline avionics and potential improvements against various mission requirements and environmental conditions. The most

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critical needs identified in the study were night-vision aids and improved navigation capability. (

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AN INVESTIGATION OF AIRBORNE DISPLAYS AND CONTROLS FOR SEARCH AND RESCUE

JANAIR Report No. 731001

Volume VIII: Army MEDEVAC Avionics Capability Study

A.L. Jones
W.A. Dalhamer
R.J. Kirk

FOREWORD

This final report is submitted as partial fulfillment of the Office of Naval Research Contract No. N00014-69-C-0460, Contract Authority NR 213-072. Commander J. E. Hammack of ONR (Code 461) served as chairman of the Joint Service SAR Working Group that monitored the study. The other group members were:

- U.S. Army: Mr. A. Linder, Mr. T. Maloney
- U.S. Navy: Mr. S.C. Merriman, CDR R.J. Hartranft
- U.S. Coast Guard: CDR B.L. Solomon, LCDR L.A. Kidd
- U.S. Air Force: COL R. Ravenelle, Mr. R.A. Bondurant

Work described in this report was performed by Honeywell's Systems and Research Center during the period of November 1972 through August 1973. Mr. A.L. Jones served as Program Manager; Mr. W.A. Dalhamer and Mr. R.J. Kirk did the technical analyses for the program.

Technical inputs necessary to perform the study were received from CAPT G. Foust and ten other combat experienced MEDEVAC pilots of the 507th Air Ambulance Company stationed at Ft. Sam Houston, San Antonio, Texas.

This report is published as Volume VIII of a series of reports entitled, "An Investigation of Airborne Displays and Controls for Search and Rescue (SAR)." This study is an extension of the program reported in Volumes I through VII. Reports covering previous investigations were:

- Vol. I — JANAIR Report No. 701219: Summary
- Vol. II — JANAIR Report No. 701220: SAR Requirements and Technological Survey
- Vol. III — JANAIR Report No. 701221: Avionics Analysis and System Synthesis
- Vol. IV — JANAIR Report No. 701222: Results of Honeywell/Bell Mockup Review
- Vol. V — JANAIR Report No. 720901: Avionics Requirements for a Utility Aircraft
- Vol. VI — JANAIR Report No. 720902: Avionics Requu rements for the HH-53C Helicopter
- Vol. VII — JANAIR Report No. 730702: Navy Combat SAR Avionics Capability Study (1972-1974 Era)

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SECTION I

INTRODUCTION AND SUMMARY

This study is the last of a series of four sponsored by the Joint Services SAR Group of the JANAIR Committee to investigate the current Search and Rescue avionic requirements and capabilities for the Navy, Coast Guard, Air Force and Army. This Army study was based on survey-type interviews of combat experienced MEDical EVACuation (MEDEVAC) pilots and on surveys of avionic equipment currently in use on the UH-1H aircraft and equipment available as a supplement or replacement; all aspects were examined in light of the Army's operational search and rescue requirements.

The SAR (MEDEVAC) charter for Army Air Ambulance companies consists of the following primary functions:

- Area medical evacuation of selective patients
- Emergency movement of medical personnel and supplies to meet a critical requirement
- Uninterrupted delivery of whole blood, biological and medical support to area of need. The charter extends throughout the combat area and is independent of time of day or weather conditions. Under the Military Assistance to Safety and Transportation(MAST) program, the charter has been expanded to include use of the MEDEVAC capabilities and equipment to respond to civilian emergencies requiring rescue and/or evacuation.

It is expected that the definition of current needs will be valid for near future civilian emergency missions as well as combat MEDEVAC missions. However, the civilian flight environment with differing navaids, communication frequencies and often denser traffic situations may pose additional constraints on avionic requirements. Analyses of these constraints were beyond the scope of this investigation.

The major conclusion of the study is that current UH-1H helicopters used for MEDEVAC operations are very poorly equipped for night or any IFR operations. Although many night/IFR missions were flown in Vietnam and other locations, they had to be done with severely reduced efficiency and high risk factors.

The helicopters had no vision-aid avionics equipment to assist in penetrating hostile areas or for searching out and pinpointing rescuees or destinations during night operations. Analyses of night-vision goggles, LLLTV, and FLIR vision-aid systems indicated that each unit would greatly improve night capability. Night-vision goggles, in particular, could be easily added to current avionics at very low cost.

Navigation is done currently by compass, landmark identification, and VOR or beacon homing when available. This equipment is not adequate for IFR operations and, at best, marginally adequate for night operations. A radar altimeter is considered essential for low-level flight and hover/landing functions. A radio aid giving a complete position fix such as Tacan, VOR/DME, or LORAN, rather than "angle only" should be included in the system. Because radio navaids are often unavailable in combat areas or can be picked up only intermittently in low-level flight, a Doppler nav system could be of value for penetrating hostile areas.

SECTION II

MEDEVAC OBJECTIVES AND REQUIREMENTS

The primary function of Army Air Ambulance companies is to perform MEDEVAC missions in combat areas and other locations in support of deployed Army units. A secondary function of companies stationed in the United States is the Military Assistance to Safety and Transportation (MAST) operations for providing emergency assistance to civilian agencies as well as for training flight crews. This study is concerned primarily with avionic equipment required for efficient operation of MEDEVAC missions. Any improvement in capabilities of avionics for the UH-1H helicopter in use currently for MEDEVAC, however, will probably be reflected in effectiveness improvement of MAST operations.

OBJECTIVES

Documentation reviewed and pilot interviews indicated that MEDEVAC missions (currently referred to in some air ambulance companies as "dust-off" missions) typically involve an airborne crew of four (pilot, commander -- also acts as a copilot, and two paramedics) in a UH-1H helicopter and, on the ground, one or more injured infantrymen attended by a ground rescue/medical party. The ground rescue party is typically equipped with a VHF-FM radio for communication and use as a beacon for the aircraft's homing guidance. The injured men and rescue party are typically near the FEBA, which, in Vietnam, was irregular in shape, size and location. Consequently, the MEDEVAC missions generally have had to penetrate some hostile areas on the way to the rescue location. The MEDEVAC helicopter rarely, if ever, has to penetrate hostile areas as deeply as the Air Force ARRS aircraft do in order to pick up downed pilots. Consequently, the MEDEVAC helicopters are not given armor nor armor plate.

REQUIREMENTS

Typical requirements for MEDEVAC missions were identified through interviews with 10 Air Ambulance company pilots with an average of 1.5 years combat experience in Vietnam. A series of questions was developed as a basis for interviewing combat pilots to determine typical requirements for the conditions under which SAR missions are conducted by an Army MEDEVAC team. The information desired was their estimation of how frequently a particular condition is encountered whenever a rescue incident occurs. This estimate is in terms of approximate percent of all missions to which each condition applied. The summary of average mission requirements as compiled from the interviews is as follows:

INTERVIEWEE EXPERIENCE

Rank: 4-CW2, 1-CW4, 4-Captains, and 1-Major

Combat Time· 1.5 years in Vietnam, average

Aircraft Hours: Total: 13,050 Average: 1,450

MEDEVAC Hours: Total: 12,050 Average: 1,339

AVERAGED MISSION REQUIREMENTS

1. Environmental Conditions

a. Enroute and Search

Rough Terrain - Smooth Terrain	68%	32%	
Combat Threat - No Combat Threat	65%	35%	
Dense - Medium - Light Foliage	52%	30%	18%
Swampy Areas - Desert	47%	53%	
Mountainous Terrain: Rough-Smooth	54%	46%	

b. At Recovery Zone

Dense - Medium - Light Foliage	53%	17%	30%
Combat Threat - No Combat Threat	59%	41%	
Rough Terrain - Smooth Terrain	59%	41%	
Mountainous Rough - Smooth	63%	37%	
Hazardous Orbiting - Safe (Terrain)	43%	57%	

c. General

Radius of Mission: 50 nm - 51 to 100 nm - 100 nm	85%	10%	5%

2. Flight Conditions

a. Enroute

VFR (300/1 mi) - IFR	78%	22%
Stormy - Calm Weather	30%	70%

b. At Recovery Site

VTR (300/1 mi) - IFR	81%	19%	
Light - Moderate - Heavy Turbulence	64%	13%	23%

c. At Base

Landing Aids - None	38%	62%	

d. General

Day - Night - Both	59%	28%	13%
Hot - Temperate - Cold Climates	71%	29%	0%

3. <u>Team Configuration</u>

Single - Multiple Service	91%	9%	
Single - Multiple Aircraft	81%	19%	
Personnel Required: 4			
Rescuees:			
Communicative-Intermittent-Noncommunicative	62%	13%	25%

The missions call for flight under adverse conditions (combat areas, night, severe weather, and hazardous terrain) for relatively high percentages of the time. In addition, over 80 percent of the flights are single aircraft operations. Crews must rely on their own systems for fast penetration and location of, and drop to, the recovery zone without navigational or cover support from other aircraft.

Avionic equipment either on board the UH-1H helicopters or available for a MEDEVAC mission does not provide any significant supplemental capability to the crew for undertaking night or adverse weather operations. Various agencies in the Army have recognized these avionics shortcomings and have undertaken research, development, and requirement upgrading projects to provide improved avionics capability. Examples of these projects are ECOM's Night MEDEVAC, HENILAS, and Low-Level Night Operations (LLNO) programs. The Aviation Branch of the Office of the Army Surgeon General and CDC have been engaged in preparing a Preliminary Material Need (PMN) and a Required Operational Capability (ROC) for "Aerial Medical Evacuation Avionics/Stabilization System." These programs have been directed toward a fairly close-in upgrading of the MEDEVAC helicopters. For long-range needs of all Army helicopters, CDC has prepared a Proposed Material Need (Engineering Development), PMN (ED), for a Helicopter Integrated Multifunction System (HIMS). The objective of this Material Need

is development of an integrated, self-contained, multifunction system for Army helicopters in the Army 80 (1975-80) time frame that will facilitate mission accomplishments during day/night Instrument Meteorological Conditions (IMC). The missions to be covered are assault, rescue and recovery, attack, command and control, reconnaissance and resupply. This MN is being held in abeyance until 1974 when it will be reviewed with respect to accepted operational concepts and technological advances to determine technical feasibility and cost effectiveness.

SECTION III

OPERATIONS SURVEY RESULTS

CHARTER

Combat -- The U.S. Army MEDEVAC company or detachment provides: 1) area medical evacuation of selective patients, 2) emergency movement of medical personnel and accompanying equipment and support to meet a critical requirement, and 3) uninterrupted delivery of whole blood, biological and medical support when there is a critical requirement. The combat area to be covered for the operations of a company or detachment is normally defined by the area of responsibility of the medical command. However, at times the area of coverage is limited only by the operational range of the aircraft.

MAST -- Military Assistance to Safety and Transportation (MAST) is a tri-agency program initiated in 1970 to determine the feasibility of using military rescue personnel and equipment to respond to civilian emergencies. Presently the program is in a somewhat expanding mode of operation. It has been recognized as providing valuable assistance to civilian agencies, in addition to effectively utilizing and training military personnel and utilizing equipment designated for emergency activities. In the few short months of existence, the 507th Air Ambulance company, San Antonio, Texas, a test site for the MAST program, has responded to 736 missions and evacuated 830 persons for a total of 1083 flight hours as of 15 January 1973. The 498th and 507th Air Ambulance companies are on 24-hour call to respond to civilian emergencies within a 100-mile radius. These emergencies can be called by a hospital administrator or by an emergency unit, such as the highway patrol.

Although these evacuation activities are not combat oriented, they are noteworthy for this study because of their concomittant need for on-board avionics to supplement the pilot's sensing and controlling capabilities. This need for electronic and visual aids occurs because the airspace involved is often more densely populated with aircraft near large metropolitan areas than in a combat situation.

FORCE

Combat -- The MEDEVAC pilots flew H-13, H-23, H-19 and UH-1H helicopters in SEA. As of 1966, the UH-1H helicopter became the dedicated aircraft for MEDEVAC missions.

There are five MEDEVAC companies in the Army: two in the United States, one in Korea, one in Europe, and one in Germany. A company is comprised of 25 UH-1H aircraft and 201 men (officers and enlisted personnel). A company is divided into four flight platoons, each with six aircraft and approximately 50 men. None of the MEDEVAC aircraft carry armament.

MAST -- There are five locations presently participating in MAST activities. All are located stateside. The size of a MAST unit is the same as a detachment, 6 vehicles and 43 to 50 men.

MISSION

Experienced MEDEVAC pilots from the 507th Air Ambulance company were interviewed to obtain mission requirements and background data as related to their combat situation experience. The pilots were asked to consider the questions concerned with vehicle and avionics problems as they relate to the UH-1H helicopter. Survey responses are summarized in this section. The listing of average mission requirements is given in Section II.

The pilots interviewed ranged in rank from CW2 to Major. Most combat experience of the interviewees was accrued in Vietnam. The pilots spent a minimum of one year in Vietnam, and 50 percent spent more time there. Helicopter experience of the pilots ranged from 800 to 4800 hours with an average of 1450 hours per pilot. The majority of their experience was accumulated during MEDEVAC missions, an average of 1207 hours per pilot. A typical MEDEVAC mission is accomplished by a team of four people (aircraft commander, pilot, crew-chief, and medic). Eighty-five percent of the missions were accomplished within 50 miles of their home location. The missions were flown 91 percent of the time without involvement of another service. Very little assistance from other aircraft was received with 85 percent of the missions accomplished by single aircraft.

Over half (59 percent) of the enroute portions of missions were flown during daylight hours and 78 percent of those were under VFR flight conditions. A majority of the missions occurred during calm and hot weather conditions, 70 and 71 percent, respectively. At the recovery zone, however, visibility was slightly better than enroute, 81 percent VFR. Virtually no turbulence occurred during 64 percent of the missions.

Sixty-seven percent of the terrain traversed was categorized as rough, and mountains accounted for 54 percent of the roughness. The majority of the mission areas consisted of dense to moderate foliage, 82 percent, half of which was categorized as swampy, 47 percent. Approximately two-thirds of the missions, 65 percent, were exposed to combat fire during the enroute portion of the flight profile. At the recovery zone the conditions were essentially the same as enroute with the exception of a reduction in the density of the foliage from 82 to 69 percent. Forty-three percent of the orbits were conducted under hazardous conditions in or near the recovery zone.

Each pilot was asked to give his interpretation of crew members' responsibility and associated workload for segments of the flight profile.

There was virtually no disagreement as to crew members' responsibility for the cruise and search phases. They were:

Crew Member	Responsibility	Workload (Percent)
Aircraft Commander	Aircraft and crew safety, communications	68
Pilot	Flying the aircraft	58
Crew Chief and Medic	Obstacle clearance, traffic monitor, search for landing zone (LZ)	34

However, once the rescuees location was spotted, the pilots had differing opinions as to who flies the aircraft. Fifty-seven percent stated the aircraft commander assumed control of the aircraft during this phase and monitored the flight instruments while maintaining communications with interested parties, e.g., gunships (workload 87 percent). The pilot either flew the aircraft or monitored the progress of the mission, e.g., displays, controls, communications, etc. (workload 86 percent). The crew chief and medic's responsibilities are to clear the aircraft from obstacles, maintain constant "talkathon" with the aircraft commander giving control instructions, and be on the lookout for enemy activity (workload 86 percent).

The pilots disagreed on the duties of each member during hoist or land portion of the mission. Fifty-six percent of the pilots stated the aircraft commander flies the aircraft during either hoist or land (one pilot stated the commander flies during land but not hover). The commander, in conjunction with piloting tasks, maintains communication, monitors the instruments, clears the aircraft and instructs the pilot during the hoist mission (workload 90 percent). The pilot, if not flying the aircraft, monitors instruments and assists in communications (workload 93 percent). The crew chief clears the aircraft from obstacles, operates hoist (if hoist operation), looks for rescuees, and assists the medic in loading patients. The medic performs medical preparations and assists the crew chief in his duties (workload for both 87 percent). The crew members and their associated responsibilities are presented in Table 1.

EQUIPMENT

The MEDEVAC pilots were asked to rate the aircraft system consisting of the UH-1H helicopter and its avionics. The rating was accomplished by comparing the UH-1H and its subsystems to what the pilots desired or believed necessary to operate a MEDEVAC mission effectively. Emphasis was placed on problems due to lack of avionic equipment or inoperative avionic equipment. Pilots

Table 1. Team Member Responsibilities as Related to Specific Portions of the Flight Profile

Flight Profile	Team Member	Workload (Percent)	Responsibilities
Cruise/Search	Aircraft Commander	68	• Overall responsibility • Navigation • Communication • Monitor instruments
	Pilot	58	• Fly aircraft • Monitor radio • Monitor instruments
	Crew Chief	34	• Obstacle clearance • Traffic observation • Search for landing zone
	Medic	34	• Obstacle clearance • Traffic observation • Search for landing zone
Approach	Aircraft Commander	87	• Fly into landing zone • Monitor instruments • Communications
	Pilot	86	• Monitor instruments • Monitor controls • Monitor communications
	Crew Chief	86	• Clear aircraft • Alert for rescuees • Alert for enemy
	Medic	86	• Clear aircraft • Alert for rescuees • Alert for enemy
Hover/Hoist	Aircraft Commander	90	• Communications • Monitor instruments • Instruct command pilot
	Pilot	93	• Fly aircraft (56 percent) • Monitor instruments
	Crew Chief	98	• Clear aircraft • Communicate instructions to pilot • Operate hoist • Surveillance
	Medic	88	• Clear aircraft • Normal medical duties
Land	Aircraft Commander	76	• Communications • Fly aircraft (56 percent)
	Pilot	74	• Monitor instruments • Fly aircraft (44 percent)
	Crew Chief	84	• Clear aircraft • Load patients • Assist medic
	Medic	87	• Normal medical duties

were asked to 1) identify deficiencies in the avionic and other systems, 2) identify functional requirements for an improved system, and 3) suggest proposed solutions.

Aircraft

The pilots were asked to comment about the airframe of the UH-1H helicopter. They felt that aircraft speed and endurance were inadequate for mission requirements, 80 and 70 percent, respectively. Most pilots expressed a desire to cruise at 150 knots with a red line dash speed of approximately 175 knots. Sixty percent stated the power of the UH-1H was adequate but were unhappy about the imposed torque limit on the transmission (engines derated from 14,000 rpm output to 11,000 rpm). Most pilots who felt endurance to be inadequate expressed a desire to increase the time and range by 50 percent to cover missions up to 150 nautical miles radius. The aircraft was considered to have insufficient volume for present missions, and insufficiency would be more of a problem in the future. Most pilots felt that an increase in volume to accommodate 6 litters would be sufficient.

Seventy percent of the pilots felt the aircraft was inherently stable in the pitch and roll axes with some limitations imposed by the tail rotor control.

Avionics

Flight Controls --

SAS -- Even though pilots previously stated the aircraft was inherently stable, 80 percent felt some kind of stability augmentation system was needed for the pitch and roll axes. They felt that the increasing demands likely to be imposed on the pilot because of an increase in IFR flight during the 1970 decade would result in poorer flight control and increased workload unless the pilot was assisted in some manner. However, only 50 percent felt a coordinated turn system was necessary.

AFCS -- Most pilots had little, if any, experience with an autopilot system. However, they felt one will be needed to provide heading and altitude hold and thereby unburden the pilot of some of his piloting workload during IFR conditions. This addition was felt to be important for long missions. The most important requirement for assistance through automation was considered to occur during hover.

The pilots expressed a definite need for heading and altitude hold during hover. This would allow the pilot to devote his attention to other tasks, such as hoist operation monitoring, etc.

Displays -- Pilots were not satisfied with existing displays for flight control and flight status. Many pilots were not aware of more sophisticated control and display systems presently available. One pilot stated, "When you live in ignorance you learn to make do with what you have." Of the aircraft assigned to the U.S. Army 507th Air Ambulance Company, no two display panels are configured the same. When a pilot responds to an emergency, he uses the first available aircraft. Thus, he finds out what equipment he has during his preflight checkout. A schematic of an existing cockpit layout for the best configuration inspected is presented in Figure 1.

The normal engine instruments, fuel, engine oil, torque, etc., were considered acceptable. Two displays, the CDI and the clock, were poorly positioned, being obscured by the control stick.

Unfortunately, pilots are not familiar with the Flight Director System (FDS) nor its concept. The pilots were asked if one was desirable or necessary to assist in future requirements. Twenty percent did not feel knowledgeable enough in their conceptualization of an FDS to respond fairly. Some pilots felt that all that is needed for IFR flight is vertical velocity, heading and altitude indicators. Irrespective, other pilots felt some form of command information is essential for IFR flight requirements of the future. They felt that guidance information (glideslope, localizer, course error, and altitude error) is the bare minimum for flight under IFR conditions, especially in a high aircraft density area. The pilots stated the aircraft flown on MEDEVAC or MAST missions were "lucky" to have operational VOR (VHF) and/or UHF receivers. Localizer error, if available, when flying ILS was displayed on an ID-250 (cross pointer). The need for the vertical path indicator (horizontal bar) was imperative due to lack of a glideslope receiver or altitude hold linkage to an altitude sensor.

The pilots stated that other desirable display modifications were to add radar altitude for terrain avoidance and obstacle clearance and to configure the commander's panel (left-hand side) with the same displays as the pilot's panel. Presently, aircraft commanders have to lean over the center console in order to get accurate readings while monitoring the displays. This is an undesirable situation since it places the commander in an awkward position and reduces his capability to perform other duties. Clearance of the left side of the aircraft from possible threat or taking over the controls quickly become problems in this strained position.

Navigation/Guidance -- Pilots were asked if present equipment was adequate to solve enroute, terminal, search/rescue, and terrain avoidance navigational problems anticipated during the 1970 decade. The present system is comprised of UHF, VHF, and FM receivers which afford VOR/LOC (if high enough frequency on VHF) and FM homing capability when the equipment is operational. The response was unanimous -- no. The pilots stated that dual VOR, TACAN, and FM were the three system configurations considered essential to provide the bare minimum navigation and guidance assistance.

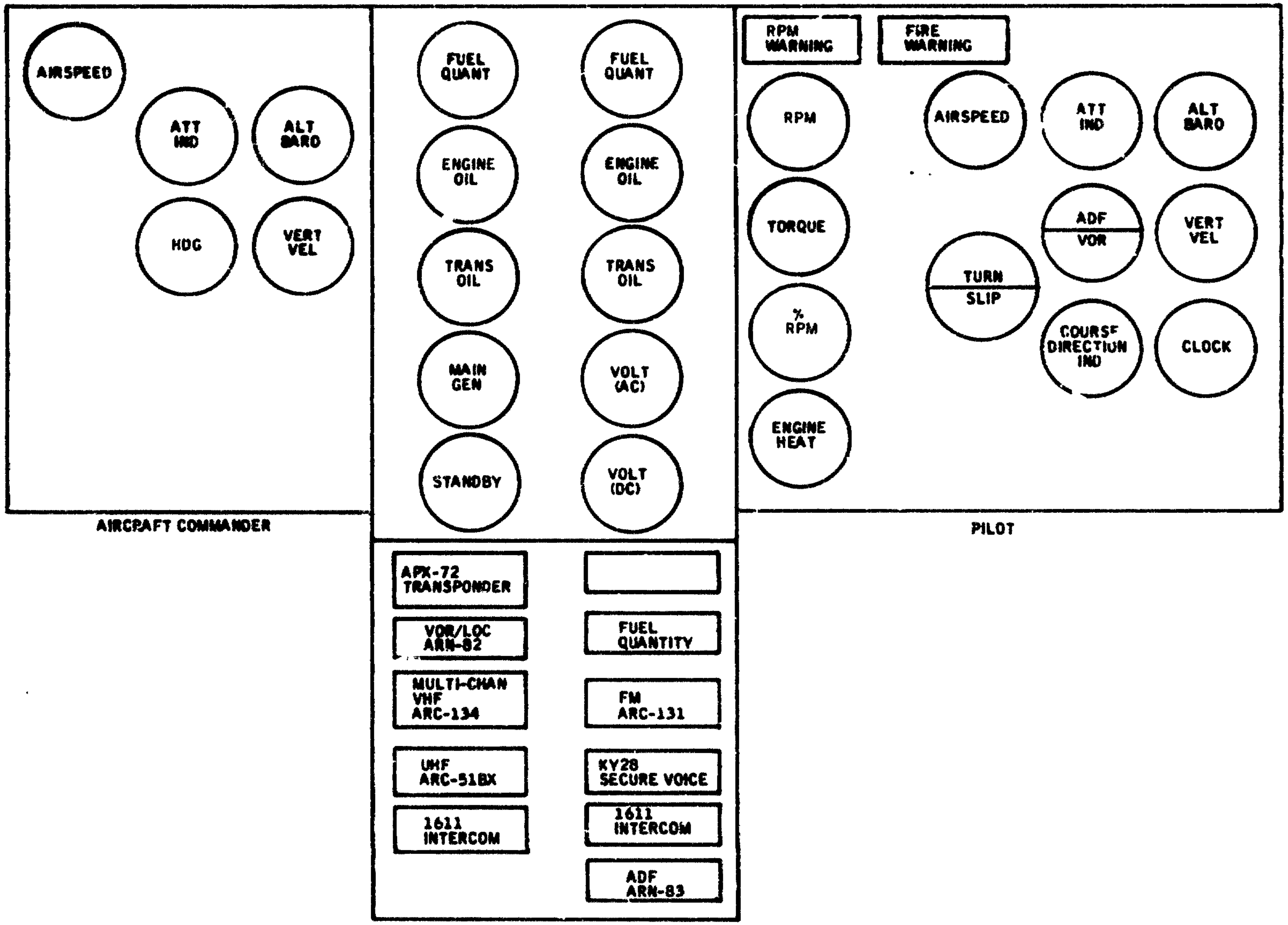

Figure 1. UH-1H Cockpit, SN 70-16280, Representing the Best Configuration in the 50th Air Ambulance Fleet

The pilots presently navigate by using terrain maps, compass headings and vectoring by radar control from home base to and from the recovery zone. Occasionally, the pilots are vectored into the LZ by radio communications with the search party. The pilots expressed a need for radar altimeter and homing systems to assist in recovery zone operations. They felt these would assist in rapid acquisition and evacuation of the rescuees. Presently, the pilots must circle the recovery area until some visual contact is made. While doing this, the aircraft becomes a likely target for enemy fire. The pilots stated other systems needed were the Doppler navigator and map plotter. Fifty percent of the pilots stated the UH-1H at one time had a DECCA system (radio nav with automatic plotting equipment), but it was taken out of the aircraft due to unreliability and nonavailability of replacement parts.

Ground-based terminal area navigation aids at the home base are virtually nonexistent. The only guidance assistance was through GCA and that was available only on rare occasions. The pilots followed the GCA commands by using barometric altitude, vertical velocity and compass heading. The pilots expressed a desire for ILS approach guidance receivers to obtain greater azimuth and vertical precision. This equipment is important in a high aircraft density area such as stateside, but it has limited application in the present combat environment due to nonavailability of ground-based guidance systems. However, it is conceivable that future combat environments will have portable ILS guidance equipment at numerous locations (possibly even the rescue sites).

The UH-1H does not have any terrain avoidance system/information. As previously mentioned, the pilots expressed a need for at least a radar altimeter to provide absolute altitude above the ground. The need for this information becomes critical under low-visibility conditions such as night or adverse weather. The altimeter would provide the pilots with the crudest forms of terrain avoidance. Some of the pilots stated they prefer a pictoral presentation of the terrain by means of a display system with a field of view of about 45 degrees. This display would require a radar, LLLTV or FLIR sensor and a background projection on a plasma display, or a CRT, and would be expensive. The pilots were asked if there is a need for a navigation computer on board the aircraft. The UH-1H does not presently have one. The pilots were not aware of the need for the computer, but recognized a computer would be needed for the flight director system (FDS). The FDS was acknowledged to be a valuable aid if the requirement to navigate and fly in adverse weather conditions increased. They felt command information about heading and distance to a selected waypoint would be desirable in anticipated navigational problems of the future. This capability would, of course, be included in the FDS.

Communications -- Sixty percent of the pilots felt the band range on the existing communication network was adequate for air-to-air, air-to-ground, and interservice communications. Some pilots felt, however, that additional frequencies to overlap civilian frequencies were needed mainly on VHF and

FM. Twenty percent of the pilots stated the aircraft they flew did not have VHF, and they felt it was essential. The efficiency of the existing network was classified as good for UHF and VHF, when available, but poor for FM signals. This was mainly due to unreliability of the system and poor maintenance. A majority of the pilots felt a duplication of all communication sets (UHF, VHF, FM) was necessary for the 1970 decade (see the navigation section). This would provide greater flexibility in communications, e.g., UHF is needed to work with the Air Force. A frequency preset feature is considered important for all communication systems. Presently only the UHF sets have this feature.

Pilots were asked to comment on the need for communication with the rescue party. They all felt that communication with the party was an essential part of the search and rescue operations. The current capability is only a marginally acceptable configuration to satisfy current or future requirements for locating the rescue party. Presently an FM set is used to establish voice communication (if available) with the rescue party, however, the set is limited in range due to insufficient power. A more powerful unit is needed for effective homing capability.

The pilots were asked to comment on the need for ECM. Fifty percent felt the ECM feature was not necessary for a MEDEVAC aircraft. Presently the UH-1H has a KY-28 scrambler for positive identification of a communicative message. However, this system has inadequate power to be of significant use since positive identification is accomplished too close to the recovery zone. This feature also requires ground troops to have the same system (transmitter); this is not always available.

Vision Aiding Systems -- The pilots were asked to comment on any experience they may have had with visual aiding systems. Essentially all stated they had none. The typical visual system used in the UH-1H was eyeball. Consequently, the pilots have to depend on their inherent visual system and that of other crew members as the means of searching the terrain for the rescue party. This is undesirable since a relatively long period of aircraft exposure to hostility may occur during the time required to adequately search a specific area. During this time, the crew members visually inspect the area for cues, such as a strobe light, reflection, or flare signal which would identify the location of the rescue party. This can be a long and tedious process since it requires unobstructed line of sight with ground personnel, friend and foe. The eyeball procedure is virtually impossible during low visibility conditions. During night missions, when the party is located, the pilots must use their landing lights to provide visibility. A night vision enhancement system could eliminate the use of lights during landing where covertness is required. A visual aiding system would also allow the pilot to make effective use of terrain features to provide cover during his penetration and approach to the landing zone, e.g., hills, trees, etc. Although pilots were unfamiliar with visual aiding systems, they felt conceptually that these features would be invaluable in a conflict situation.

Systems Monitoring -- The pilots were asked to comment on adequacy of the monitoring system. The system was described as adequate by 50 percent of the pilots. The remaining 50 percent felt some simplification of the system is needed. For example, they felt the system could be simplified by incorporating a central auditory signal for cueing purposes and an advisory panel for rapid assessment of the problem. On the other hand, some pilots stated that crucial parameters (fuel control, electrical, hydraulic, magnetic plugs, and fire warning) were not adequately monitored. It is suggested that the monitoring system incorporate an auditory alarm that is triggered simultaneously with the appropriate system monitor indicator. One subject felt that a voice alert system would be useful.

Some differences of opinion existed between pilots as to how often they scan the monitoring instruments. This ranged from a constant monitoring (one-way scan of the panel) of the entire system to a periodic check of the Master Caution and Fire Warning lights. The scan rate differed with weather and IFR conditions.

Auxiliary Systems -- The pilots were asked to comment on the design and operation of the recovery hoist on the aircraft. They agreed that the hoist operation and intent was good. Pilots do not like to have to use the hoist although they recognize it as a valuable backup for mission success. Since MEDEVAC missions are conducted primarily over land, the pilots preferred to land and pick up the rescue party if possible.

The pilots felt the reliability of the hoist was unsatisfactory. Major complaints were the portability, speed, and durability of the hoist. The pilots felt that the hoist unit should be permanently attached to the aircraft. This configuration would result in less wear on the hoist and associated parts since installation and removal often damage equipment.

A need for a remote Monitoring and Control System (MCS) that would give up-to-date knowledge of the status of the hoist operation was stated by the pilots. They felt this to be necessary to maximize the probability of a successful mission. The MCS would consist of a hoist control and cable-cut capability located on the pilot's side of the cockpit, that he could use as a backup or override control. As it stands, the pilot has no way of determining the amount of cable extended. Perhaps a simple digital readout to indicate footage extended would be of assistance. The pilots feel this capability (override and cable-cut) important since 17 percent of the missions resulted in a hoist operation even though they preferred to land whenever possible.

The most common recommendation under the auxiliary systems category was an expressed need for controllable searchlights. Use of a simple swivel platform for the landing lights would provide the directional light capability needed for effective search procedures at night over nonhostile areas.

Fuel Jettison -- The UH-1H does not have fuel jettison capability. Sixty percent of the pilots considered this feature unnecessary. Those who favored it felt it should only apply to the external or auxiliary fuel tanks.

Lighting -- Comments by the pilots on lighting systems and lighting problems encountered in the aircraft indicated over-the-shoulder lighting from daytime ambient conditions and lights shining from the rear compartment onto the face of the display panel make it difficult to read displays. A glare shield strategically placed over the display panel would greatly reduce the amount of outside light hitting the displays. A curtain placed behind the pilot and aircraft commander would eliminate the over-the-shoulder lighting problem. Many pilots felt the existing red light system was inadequate for reading and interpreting displays under nighttime operations. They suggested that the red lights be replaced with another color, preferably soft white. Other services have made the transition to white lighting and are pleased with results.

AVIONICS MAINTENANCE

The pilots were asked to comment on system maintenance frequency, especially as to which systems were bad. They unanimously agreed that the radio (FM) was the system that most frequently needed maintenance. There were three reasons for the amount of time this system was inoperative. First, the availability of checkout and repair equipment was nonexistent, placing a heavy requirement on skilled maintenance experts. Secondly, the skill of typical maintenance personnel was adequate for first echelon maintenance only. Thirdly, when a problem was identified, the availability of parts was very poor. Some pilots felt the availability of parts to be the major problem in maintenance.

SECTION IV
OBJECTIVES VERSUS CAPABILITIES ANALYSES

CHARTER

The U.S. Army MEDEVAC companies have the dual charter of transporting medical supplies, personnel, and patients in military situations including battlefield conditions and performing similar functions for civilian agencies in emergency situations. This charter requires capability for quick response on a 24-hour basis under all weather conditions. Although night missions in severe weather have been satisfactorily accomplished due to crew skill and bravery, the companies are very poorly equipped, by today's standards in avionics state of the art, to perform night/IFR missions.

MISSIONS AND EQUIPMENT

The fact that MEDEVAC units have flown night missions and hostile overland missions does not demonstrate that their SAR aircraft are equipped to perform these kinds of missions with a high probability of success. In fact, they are poorly equipped to do so. To examine the benefits to MEDEVAC that could accrue from the application of vision-aiding avionic equipment, evaluation matrices rating equipment versus probability of mission phase success for various environmental and search conditions have been prepared. For this analysis, the SAR mission has been narrowed down to its two most pertinent and potentially difficult phases. These phases are the enroute penetration and the localization (destination pinpointing and pickup) phases.

For the enroute penetration phase, environmental conditions relating to visual conditions, terrain, obstacles and hostility were stipulated and a judgment was made as to whether or not, under various combinations of these conditions, penetration to the destination was feasible for the following sets of presently available SAR-related equipment:

- The presently configured UH-1H MEDEVAC baseline equipment (no vision-aiding equipment)
- The addition of Night-Vision Goggles for the pilot or aircraft commander
- The addition of search radar
- The addition of terrain-avoidance radar
- The addition of LLLTV
- The addition of FLIR

Judgments presented in Table 2 were conditioned by the following assumptions:

1. The navigation, communication, flight control, monitoring and auxiliary equipment are at least adequate to permit unrestricted helicopter operation under daylight/VFR conditions, as indicated by results of the survey, if existing installed equipment is operable.

2. The distance of penetration required is not greater than the round trip fuel supply can provide.

3. Hostile area refers to an area where the enemy has radar, AA guns, rockets, and missiles or troops, and the helicopter pilot has to hug the terrain to avoid detection, tracking, and interception by ground- or air-based weapons.

4. Obstacles include trees, hills, poles, wires, bridges, and similar items that can be detected by eyeball.

5. The pilot is accompanied by an aircraft commander who monitors the instrument panel, communicates, navigates, etc., and permits the pilot uninterrupted out-of-the-cockpit or dedicated-display viewing during nap-of-the-earth flying.

6. The night/IFR conditions are limited to weather that does not appreciably degrade the performance of vision-aiding equipment.

The judgment results in Table 2 indicate that, with the UH-1H baseline equipment, the pilot can penetrate to his destination during day/VFR conditions for all eight combinations of terrain, obstacles and hostility conditions. Under night/IFR conditions, however, penetration is not probable if the area is hostile (four out of eight conditions) due to the dangers of flying low at night, such as hitting unseen obstacles or experiencing vertigo due to the lack of a visible horizon.

For these four night/IFR hostile conditions, addition to the pilot's equipment of Night-Vision Goggles, LLLTV, FLIR, or terrain following radar will probably permit him to penetrate by providing: 1) visibility sufficient to detect obstacles and 2) a referencing horizon. Available search radars do not have sufficient resolution at close-in ranges for terrain avoidance and do not provide sufficient vertical scan information to permit a vertical situation display of the terrain.

Approximate comparative costs of the four equipments are: $10,000 for Night-Vision Goggles, $50,000 for LLLTV, $100,000 for FLIR and $150,000 for terrain-avoidance radar. Actual cost of the units could vary by a factor of two dependent on specified sensitivity, resolution, stabilization, field of

Table 2. MEDEVAC Enroute Penetration Equipment Evaluations

ENVIRONMENT				PENETRATION PROBABLE?							
Visual Conditions	Terrain	Flat or Obstacles**	Area Hostile or Safe	With UH-1H Base line Equipment	Comment	Plus NV Goggles	Plus Search Radar	Plus LLLTV	Plus FLIR	Plus Terrain Follow Radar
Day/VFR	Water	Flat	Safe	Yes						
Day/VFR	Water	Flat	Hostile	Yes						
Day/VFR	Water	Obstacles	Safe	Yes						
Day/VFR	Water	Obstacles	Hostile	Yes						
Day/VFR	Land	Flat	Safe	Yes						
Day/VFR	Land	Flat	Hostile	Yes						
Day/VFR	Land	Obstacles	Safe	Yes						
Day/VFR	Land	Obstacles	Hostile	Yes						
Night/IFR	Water	Flat	Safe	Yes	Can fly high on instruments.					
Night/IFR	Water	Flat	Hostile	No	Has to fly low – vertigo, etc.	Yes	Yes	Yes	Yes	Yes
Night/IFR	Water	Obstacles	Safe	Yes	Can fly high on instruments.					
Night/IFR	Water	Obstacles	Hostile	No	Has to fly low – hits obstacles.	Yes	No	Yes	Yes	Yes
Night/IFR	Land	Flat	Safe	Yes	Can fly high on instruments.					
Night/IFR	Land	Flat	Hostile	No	Has to fly low – vertigo, etc.	Yes	?	Yes	Yes	Yes
Night/IFR	Land	Obstacles	Safe	Yes	Can fly high over obstacles.					
Night/IFR	Land	Obstacles	Hostile	No	Has to fly low – hits obstacles.	Yes	No	Yes	Yes	Yes

*Hostile refers to enemy having radar, AA guns, rockets and missiles in area – pilot has to hug the terrain to avoid detection, tracking and interception by ground or air-based defenses.
**Obstacles include: ships, islands, trees, hills, poles, bridges, etc.

view, mount, etc. The terrain-avoidance radar is an all-weather sensor while the other units are much more severely degraded by precipitation. The radar has little value in the landing and pickup phase of the mission due to its limited resolution and scan direction.

For the destination pinpointing (localization) and pickup phase of the typical MEDEVAC mission, environmental conditions relating to visual conditions, terrain, cover and hostility were stipulated for each of the four combinations of two search situations. The search situations considered pertained to the uncertainty of the location of the target (destination) and to whether or not communication could be established through use of radio, flare, smoke, etc., aids. Two values of location uncertainty were selected: a value of one mile corresponding to uncertainties in the coordinates estimated by observers or by searchers; and a value of 100 feet corresponding to the current ability to home-in on a radio beacon.

Tables 3 through 6 present the results of judgments as to whether pinpointing can occur starting with given search conditions and taking into account environmental conditions and avionic search equipment available. Judgments were conditioned by the assumptions previously stated and, in addition, by an assumption that the aircraft commander or a crewman is free to survey the search area within the limitations imposed by environmental conditions and the vision-aiding equipment available for signs that would pinpoint target location. A hostile area, redefined for this case, refers to enemy troops being within a few hundred feet of a rescuee with a chance of reaching him first unless the MEDEVAC helicopter crew can pinpoint him within a few seconds after getting within a hundred feet of his location.

The easiest search situation is covered by Table 3 and corresponds to the rescuee's location being known to approximately 100 feet and to the rescuee being communicative. Pinpointing under these search conditions with the UH-1H baseline equipment is probable for six of the eight day/VFR environmental conditions. The two cases where pinpointing is not probable correspond to when a rescuee is covered (by trees or fog, etc.) and the area is hostile. Under these conditions, the rescuee probably would not activate a visual cue because the hostile troops would get to him before the MEDEVAC helicopter could get there to perform the rescue operation. Also, the rescuee could not talk the pilot to him because the enemy troops would track the helicopter and get there simultaneously. Under night/IFR conditions with the UH-1H baseline equipment, pinpointing is probable only when the area is not hostile, which is four conditions our of eight. Again, it is believed that the rescuee probably would not be able to use a visible signal safely in a hostile area.

All six improbable pinpoint cases just mentioned could be converted to probable by the MEDEVAC helicopter crew using either Night-Vision Goggles, LLLTV or FLIR, coupled with the rescuee using IR strobe lights or flares. The IR radiation will permit the rescuee to make a signal visible only to the

Table 3. Army MEDEVAC "Pinpointing" Requirements

Rescuee Communicative and Location Known to Within 100 Ft												
ENVIRONMENT				PINPOINTING PROBABLE?								
Visual Conditions	Terrain	Area Covered or Open	Area* Hostile or Safe	With UH-1H Baseline Equipment	Comment	Plus NV Goggles Only	Plus NV Goggles & IR Flare	Plus LLLTV	Plus LLLTV & Flare	Plus FLIR	Plus FLIR & Flare	Plus Search Radar
Day/VFR	Water	Open	Safe	Yes	Can see rescuee							
Day/VFR	Water	Open	Hostile	Yes	Can see rescuee and hold off enemy with guns							
Day/VFR	Water	Covered	Safe	Yes	Can be signaled to position							
Day/VFR	Water	Covered	Hostile	No	Not safe for visual cue	No	Yes[a]	No	Yes	No	Yes	No
Day/VFR	Land	Open	Safe	Yes	Can see rescuee							
Day/VFR	Land	Open	Hostile	Yes	Can see rescuee and hold off enemy with guns							
Day/VFR	Land	Covered	Safe	Yes	Can be signaled to position							
Day/VFR	Land	Covered	Hostile	No	Not safe for visual cue	No	Yes[a]	No	Yes	No	Yes	No
Night/IFR	Water	Open	Safe	Yes	Can be signaled to position							
Night/IFR	Water	Open	Hostile	No	Not safe for visible cue	Yes	Yes	Yes	Yes	Yes	Yes	No
Night/IFR	Water	Covered	Safe	Yes	Can be signaled to position							
Night/IFR	Water	Covered	Hostile	No	Not safe for visible cue	No	Yes	No	Yes	No	Yes	No
Night/IFR	Land	Open	Safe	Yes								
Night/IFR	Land	Open	Hostile	No	Not safe for visible cue	Yes	Yes	Yes	Yes	Yes	Yes	No
Night/IFR	Land	Covered	Safe	Yes								
Night/IFR	Land	Covered	Hostile	No	Not safe for visible cue	No	Yes	No	Yes	No	Yes	No

*Hostile – Enemy within voice range (< 200 ft) and can beat helicopter to position during slow homing of helicopter following voice instructions.

[a] NV Goggles plus IR Flares – Permits pinpointing by helicopter but not by enemy on ground; helicopter noise covers sound of firing flares.

Table 4. Army MEDEVAC "Pinpointing" Requirements

Rescuee Uncommunicative and Location Known to Within 100 Ft									
ENVIRONMENT				PINPOINTING PROBABLE?					
Visual Conditions	Terrain	Area Covered or Open	Area* Hostile or Safe	With UH-1H Baseline Equipment	Comment	Plus NV Goggles	Plus LLLTV	Plus FLIR	Plus Search Radar
Day/VFR	Water	Open	Safe	Yes	Can see rescuee				
Day/VFR	Water	Open	Hostile	Yes	Can see rescuee				
Day/VFR	Water	Covered	Safe	Yes	Can lower crewman to search				
Day/VFR	Water	Covered	Hostile	No	Not safe for crewman to search	No	No	No	No
Day/VFR	Land	Open	Safe	Yes	Can see rescuee				
Day/VFR	Land	Open	Hostile	Yes	Can see rescuee				
Day/VFR	Land	Covered	Safe	Yes	Can lower crewman to search				
Day/VFR	Land	Covered	Hostile	No	Not safe for crewman to search	No	No	No	No
Night/IFR	Water	Open	Safe	Yes	Can use helicopter lights to search				
Night/IFR	Water	Open	Hostile	No	Not safe for crewman to search	Yes	Yes	Yes	No
Night/IFR	Water	Covered	Safe	Yes	Can lower crewman to search				
Night/IFR	Water	Covered	Hostile	No	Not safe for crewman to search	No	No	No	No
Night/IFR	Land	Open	Safe	Yes	Can lower crewman to search				
Night/IFR	Land	Open	Hostile	No	Not safe for crewman to search	Yes	Yes	Yes	No
Night/IFR	Land	Covered	Safe	Yes	Can lower crewman to search				
Night/IFR	Land	Covered	Hostile	No	Not safe for crewman to search	No	No	No	No

***Hostile – Enemy within range of detection and potential disruption of rescue attempt (~ 200 Ft)**

Table 5. Army MEDEVAC "Pinpointing" Requirements

Rescuee Communicative and Location Known to Within 5000 Ft												
ENVIRONMENT				PINPOINTING PROBABLE?								
Visual Conditions	Terrain	Area Covered or Open	Area* Hostile or Safe	With UH-1H Baseline Equipment	Comment	Plus NV Goggles	Plus NV Goggles & IR Flare	Plus LLLTV	Plus LLLTV & IR Flare	Plus FLIR	Plus FLIR & IR Flare	Plus Search Radar
Day/VFR	Water	Open	Safe	Yes	Can be voice signaled to position							
Day/VFR	Water	Open	Hostile	Yes	Radar beacon to 100 ft then see – suppress enemy with guns							
Day/VFR	Water	Covered	Safe	Yes	Can be voice signaled to position							
Day/VFR	Water	Covered	Hostile	No	Not safe for voice or visible signal	No	Yes**	No	Yes	No	Yes	No
Day/VFR	Land	Open	Safe	Yes	Can be voice signaled to position	No						
Day/VFR	Land	Open	Hostile	Yes	Radio beacon to 100 ft then see – suppress enemy with guns							
Day/VFR	Land	Covered	Safe	Yes	Can be voice signaled to position							
Day/VFR	Land	Covered	Hostile	No	Not safe for voice or visible signal	No	Yes	No	Yes	No	Yes	No
Night/IFR	Water	Open	Safe	Yes	Can be voice signaled to position							
Night/IFR	Water	Open	Hostile	No	Not safe for voice or light	Yes	Yes	Yes	Yes	Yes	Yes	No
Night/IFR	Water	Covered	Safe	Yes	Can be voice signaled to position							
Night/IFR	Water	Covered	Hostile	No	Not safe for voice or light	No	Yes	No	Yes	No	Yes	No
Night/IFR	Land	Open	Safe	Yes	Can be voice signaled to position							
Night/IFR	Land	Open	Hostile	No	Not safe for voice or light	Yes	Yes	Yes	Yes	Yes	Yes	No
Night/IFR	Land	Covered	Safe	Yes	Can be voice signaled to position							
Night/IFR	Land	Covered	Hostile	No	Not safe for crewman to search	No	Yes	No	Yes	No	Yes	No

Hostile – Enemy within voice range (< 200 ft) and can beat helicopter to position during slow homing of helicopter following instructions.

SAR follows radio beacon to 100 ft, then detects an IR flare fired by the rescuee.

Table 6. Army MEDEVAC "Pinpointing" Requirements

Rescuee Uncommunicative and Location known to Within 5000 Ft									
ENVIRONMENT				PINPOINTING PROBABLE?					
Visual Conditions	Terrain	Area Covered or Open	Area Hostile or Safe	With UH-1H Baseline Equipment	Comment	Plus NV Goggles	Plus LLLTV	Plus FLIR	Plus Search Radar
Day/VFR	Water	Open	Safe	Yes	Can use visual pattern search				
Day/VFR	Water	Open	Hostile	Yes	Can use visual pattern search				
Day/VFR	Water	Covered	Safe	No	Need too extensive on surface search for swimmer	No	No	No	No
Day/VFR	Water	Covered	Hostile	No	Can't do extensive surface search	No	No	No	No
Day/VFR	Land	Open	Safe	Yes	Can use visual pattern search				
Day/VFR	Land	Open	Hostile	Yes	Can use visual pattern search				
Day/VFR	Land	Covered	Safe	Yes	Can do extensive surface search				
Day/VFR	Land	Covered	Hostile	No	Can't do extensive surface search	No	No	No	No
Night/IFR	Water	Open	Safe	No	Can't use helicopter lights for search (illuminated area too small)	Yes	Yes	Yes	No
Night/IFR	Water	Open	Hostile	No	Not safe to use helicopter lights	Yes	Yes	Yes	No
Night/IFR	Water	Covered	Safe	No	Need too extensive on-surface in-darkness search	No	No	No	No
Night/IFR	Water	Covered	Hostile	No	Can't do extensive on-surface search	No	No	No	No
Night/IFR	Land	Open	Safe	No	Need too extensive search in dark (illuminated area too small)	Yes	Yes	Yes	No
Night/IFR	Land	Open	Hostile	No	Not safe for surface search	Yes	Yes	Yes	No
Night/IFR	Land	Covered	Safe	No	Need too extensive surface search in dark	Yes	No	No	No
Night/IFR	Land	Covered	Hostile	No	Not safe for crewman to search	No	No	No	No

Hostile – Enemy within range of detection and potential disruption of rescue attempt (~ 200 Ft)

person on the helicopter wearing Night-Vision Goggles or monitoring a FLIR or LLLTV. The search radar would be dependent on the rescuee carrying a radar reflector, but, even with a reflector, the resolution of the reflecting spot on the radar screen at close range (100 feet) would be too gross to pinpoint the source location.

With only Night-Vision Goggles, LLLTV or FLIR (that is, without an IR light flare), only two of the six initial improbable pinpoint cases in Table 3 can be converted to probable. Similarly, for the situation where the rescuee location is known to 100 feet, but he is uncommunicative (see Table 4), the baseline equipment leaves the same six environmental conditions as improbable for pinpoint. Two of these cases, however, can be converted (the night/IFR land or water, open, hostile area, conditions) to probable by the use of Night-Vision Goggles, LLLTV, or FLIR. Use of IR signals cannot be assumed here, since the rescuee is incommunicative.

For the search situation where the location of the rescuee is known to approximately one mile (5000 feet) and he is communicative (see Table 5), the radio beacon and voice signaling can reduce the 5000-foot location uncertainty to 100 feet, and this set of results (Table 5) reduces to the same set as presented in Table 3.

Results for the uncommunicative and 5000-foot location uncertainty situation are presented in Table 6. This situation requires either a patterned air search or an on-surface search. The UH-1H baseline equipment makes pinpoint probable in only 5 of the 16 environmental condition combinations. Adding Night-Vision Goggles to the equipment, however, doubles (10 out of 16) the number of cases where pinpointing is probable. Adding FLIR or LLLTV increases the number of cases of probable pinpointing by four (9 out of 16). The one case less for FLIR or LLLTV than for Night-Vision Goggles is because goggles can be used by a crewman searching on the ground, but FLIR cannot. Search radar (because of resolution) does not add any change to what can be done using baseline equipment.

Results of these pinpointing probability analyses are summarized in Table 7. Adding the cheapest equipment, Night-Vision Goggles, to the MEDEVAC helicopter shows the greatest increase in the percentage of condition combinations under which pinpointing of the rescuee is probable (17 percent -- from 55 to 72 percent). By adding IR flares or strobe lights to the rescuee's equipment, the percentage of probable pinpoints is raised another 12 to 84 percent. Adding FLIR or LLLTV is essentially equally effective. Search radar is ineffective due to its poor resolution at close ranges. These latter systems all presently cost on the order of 50 to 150 thousand dollars per set, whereas the Night-Vision Goggles presently cost on the order of 10 thousand dollars per set and probably would be easier and cheaper to maintain.

Table 7. Effect of Adding Vision-Aiding Equipment on Pinpoint Probability

Search Condition	No. of Environmental Condition Combinations (Out of 16 Possible) for Which Pinpoint is Probable							
	UH-1H Baseline Equipment	Plus NV Goggles	Plus NV Goggles & IR Flare	Plus FLIR	Plus FLIR & IR Flare	Plus LLLTV	Plus LLLTV & IR Flare	Plus Search Radar
Rescuee Communicative Location known to approximately 100 feet	10	12	16	13	16	13	16	10
Rescuee Uncommunicative Location known to approximately 100 feet	10	12	12	12	12	12	12	10
Rescuee Communicative Location known to approximately 5000 feet	10	12	16	12	16	12	16	10
Rescuee Uncommunicative Location known to approximately 5000 feet	5	10	10	9	9	9	9	5
Total Probable Pinpoint Cases	35	46	54	45	53	45	53	35
Percent Probable Pinpoint Cases	35/64= 55%	46/64= 72%	54/64= 84%	45/64= 70%	53/64= 83%	45/64= 70%	53/64= 83%	35/64= 55%

The environmental conditions for search and evacuation were confined to 16 broad categories for this evaluation. This broad breakdown serves to demonstrate that night/IFR vision aids are both useful and necessary to satisfactorily complete many missions. A finer breakdown and more detailed analysis would show that FLIR and LLLTV, with their better resolution and sensitivity parameters, have significantly better target detection performance than Night-Vision Goggles. The limited analysis of this study did not make quantitative estimates of this level of improvement in mission success probabilities.

It should be pointed out that the combinations of search and environmental conditions considered in this mission analysis are not likely to occur with equal probability for combat operations. This only means, however, that the night-IFR vision aids probably would not be needed or used as often as the preceding percentages might indicate. On the other hand, it is very significant to the potential rescuees and to the MEDEVAC helicopter crew that addition of a rather inexpensive set of Night-Vision Goggles and IR signal capability will increase their chances of surviving a distress/isolation incident in hazardous areas. These additions yield an appreciable increase in the number of combinations of adverse conditions under which the search and rescue can be completed successfully. Furthermore, the Night-Vision Goggles would, no doubt, improve the efficiency and safety of search and rescue operations under those night conditions which might permit minimally effective operations to be carried on without vision-aiding equipment.

SECTION V

R&D ACTIVITIES

Only a brief summary of R&D activities of the various services in the area of search and rescue equipment will be presented, enough to give some idea as to what has been evolving and may be available in the future. A more thorough description and discussion of the SAR R&D activities being carried on by all the services is beyond the scope of this investigation.

Equipment being developed is applicable primarily to certain distinct events or phases of a search and rescue occurrence. In Table 8 the SAR equipment, the service performing R&D, and the intended function of the equipment are listed and grouped according to the phase of their primary SAR application.

Table 8. Combat SAR Research and Development

Phase	Equipment	Function	Service Performing R&D
1. Distress Onset	1. Distress Incident Locator	To provide long range notification of a distress incident and to convey position, identification and other pertinent data.	USAF – Life Support SPO ASD, WPAFB Dayton, Ohio
	2. Emergency Position Indicating Radio Beacon (EPIRB)	To be ejected from aircraft by crew or automatically on crash impact and transmit a distress message repeatedly and automatically.	USCG – Search & Rescue Branch office of R&D, USCG Hdqtrs., Wash., D.C.
	3. Aercab (Integrated Aircrew Escape and Rescue Capability)	To permit pilot to eject and fly or glide to safe and desirable landing area.	USN – NAVAIR Syscom & NADS Johnsville USAF
	4. Discretionary Descent Device	To permit pilot to eject and float in air till mid-air retrieval is accomplished.	USAF
2. SAR Incident Planning and Coordination	1. Ground Based Computer Programs	a. To estimate rescuee locations. b. To optimize search procedures.	USCG – Search & Rescue Branch
3. Penetration of Hostile Areas	1. Terrain Following Equipment (FLIR, LLLTV, TF Radar, Night Vision Goggles)	To permit SAR vehicle to be flown under night/IFR conditions at low levels (100-300 ft) to avoid detection and attack.	USAF – MAC, Pave IMP, Pave STAR, Pave LOW USA – ECOM, LINO Program USA – Night Vision Labs
4. Pinpointing (Search and Localization)	1. Visual Locators (FLIR, LLTV, Night Vision Goggles)	To provide pilot and crew with capability of visually spotting rescuee or his signal.	USAF – MAC, etc. USA – ECOM, Night Vision Lab
	2. Radio Locators (ELF and EPD)	To provide electronic spotting of signal.	USAF – Life Support – SPO MAC

Table 8. Combat SAR Research and Development (Concluded)

Phase	Equipment	Function	Service Performing R&D
	3. Signal Generators (Radios – Survivor Locator Device Voice Communicator; Flares)	To provide rescuee with a means of communicating his exact location to the SAR aircraft.	USAF – Life Support – SPO USN – NAVAIR Syscom & NADC
5. Retrieval			
Air-to-Air	1. Line and Snare (Port)	To permit an aircraft to retrieve a parachute or a DDD in mid air.	USN
Ground-to-Air	1. Minicopter	To permit rescuee to assemble a miniature helicopter and fly out of hostile area.	USN – NAVAIR
Air-to-Ground	1. Fast Fall Hoist (High-Speed Winch)	To reduce hover time over rescuees.	USN
	2. Ground Anchor Retrieval Device (Navy) and Long Line Loiter (USAF)	To permit fixed wing aircraft to retrieve rescuee while orbiting or passing.	USN USAF

SECTION VI

RECOMMENDATIONS

Recommended improvements to the UH-1H baseline equipment for search and rescue are based on analyses using inputs from the Army MEDEVAC pilots interviewed and from other armed services personnel associated with the requirements, the research and development and the procurement of search and rescue equipment. Additional modifications requested by the Army MEDEVAC pilots are significant because they could improve overall operating efficiency of the aircraft and crew, thereby enhancing the probability of successful missions. It was not within the scope of this study, however, to analyze effectiveness versus cost of many of these pilot-suggested modifications, so they are included in this report for completeness but without validation or endorsement. Recommendations based on analyses of this study and the suggestions by the pilots are included in Table 9.

Recommendations for adding Night-Vision Goggles to upgrade penetration and pinpointing capabilities of the Army MEDEVAC crew are based on results of tests of these goggles. The Air Force ARRS squadrons have tested the goggles under project PAVE IMP and under actual combat conditions in Vietnam (see References 1 and 3). The Army has tested them under simulated combat conditions under Project MASSTER at Ft. Hood, Texas (see Reference 2).

Although these goggles cannot provide full IFR capability for MEDEVAC and MAST missions, they would upgrade the present capability of the pilot and crewmen (they presently have no night/IFR vision aids) at low cost compared with other night/IFR devices. These goggles have some human factors drawbacks that can be improved by further development. Current designs, however, have been highly and uniformly endorsed by Air Force and Army helicopter pilots. Immediate operational usage seems warranted. The goggles are tested and soon will be available in quantity. They provide a completely modular, cost-effective and significant enhancement of the capability for accomplishing rescue and evacuation missions under night/IFR conditions.

A significant improvement in navigation equipment on the UH-1H is required to take all night/IFR missions and day/VFR missions over unfamiliar territory out of a high-risk category. Present navigation aids are VOR, FM homing, LF/ADF, compass, terrain maps, and radar vectoring, when available. The radio aids are angular systems requiring two or more fixes for position. An equipment providing range or position directly, such as TACAN, DME, LORAN, or OMEGA, should be added to the avionic system. Where ground radio navaids are unavailable, a Doppler navigation system should be incorporated. For pinpointing destinations or rescuees, homing capability should be included for the UHF and VHF transceivers as well as the FM unit. Dual VOR/LOC/GS receivers and a radar altimeter should be included for terminal area operations.

Table 9. Recommended and Suggested Modifications to the UH-1H Baseline Equipment

Functions	Baseline Equipment	Recommendations Based on This Study	Additional Modifications Suggested by Users
Penetration	None	Night-Vision Goggles for Pilot	Visual Monitoring System (e.g., FLIR, LLLTV, Radar)
Pinpointing (Search and Localization)	FM Homing	Night-Vision Goggles for Crew and IR FLARE or Strobe at Rescue Site Dual FM Homing Receivers with Improved Range Capability Add UHF-VHF Homing Equipment Add Adjustable Landing Lights Radar Altimeter	Visual Monitoring System FM and UHF Homing Improvements
Flight Control	Mechanical Linkage	AFCS-Stability Augmentation System Heading Hold Altitude Hold Automatic Hover and Approach Configure A/C Commanders Panel with Same Displays as Pilot	Coordinated Turn System
Navigation	VOR/LOC FM Homing LF/ADF COMPASS	Dual VOR/LOC/GS UHF-VHF-FM Homing TACAN or DME Ranging	Doppler NAV with Map Plotter Search Radar
Communications	UHF VHF FM INTERCOM KY-28	Dual Receivers or Improve Reliability Cover Civilian Bands for MAST Functions Channel Preset Capability Needed	
System Monitoring	See Figure 1	Master Auditory Alarm	Add Central Advisory Panel
Recovery	Hoist	Cockpit Monitoring of Hoist Status	Hoist Control and Cable-Cut Capability at Pilot Station Improve Hoist Reliability
Lighting	Red Lights on Displays		Add Glare Shield, Curtain Behind Pilot Replace Red Lights with Soft White

SECTION VII
REFERENCES

(1) "40° Field-of-View Night-Vision Goggles," OT&E Final Report 3-12-72 USAF Military Airlift Command, July 1972.

(2) "Report of User Evaluation, MASSTER Test No. 154, AN/PVS-5 Night-Vision Goggles," US Army Project MASSTER, West Ft. Hood, Texas, January 1973.

(3) Combat ROC 173 "Night-Vision Goggles for SAR Forces," USAF Systems Command, Andrews AFB, Maryland, 12 January 1973.